ASTEROSEISMOLOGY AS A TOOL FOR INVESTIGATING MW DISK(S)

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Why asteroseismology?

Some of the most important ingredients for investigating MW are accurate chemical abundances and ages of stars.

- Accurate log(g) → accurate abundances

  wrong logg → wrong atm. parameters → wrong abundances

- Ageing stars, in particular RG

  With the classical isochrone fitting the error on age for red giants is bigger than 50%

- Accurate distances

Why asteroseismology?

Some of the most important ingredients for investigating MW are accurate chemical abundances and ages of stars.

- Accurate log(g) → accurate metallicities

ASTEROSEISMOLOGY!

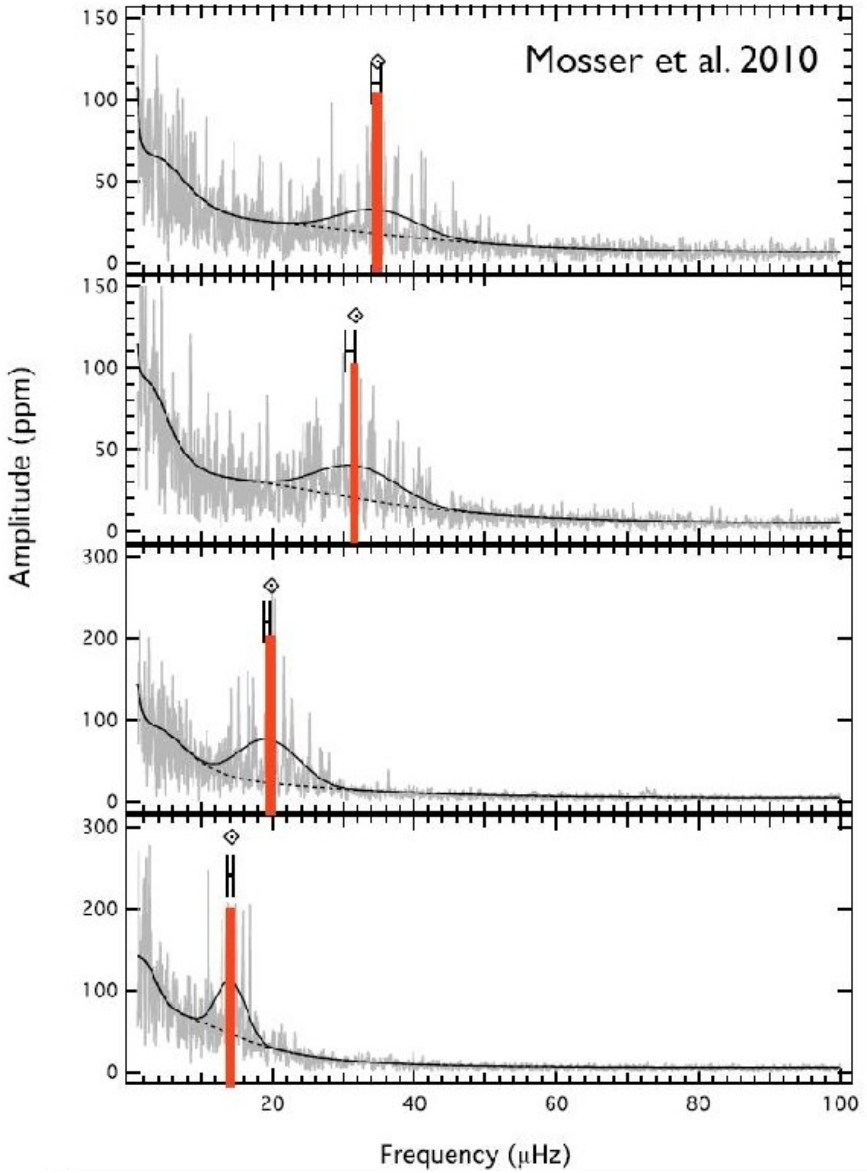
- Ageing stars, in particular RG, with accuracy

ASTEROSEISMOLOGY!

- Distances

ASTEROSEISMOLOGY!

Log(g) from asteroseismology



$$\log g = \log g_{\odot} + \log\left(\frac{\nu_{\max}}{\nu_{\max,\odot}}\right) + \frac{1}{2}\log\left(\frac{T_{\rm eff}}{T_{\rm eff,\odot}}\right)$$

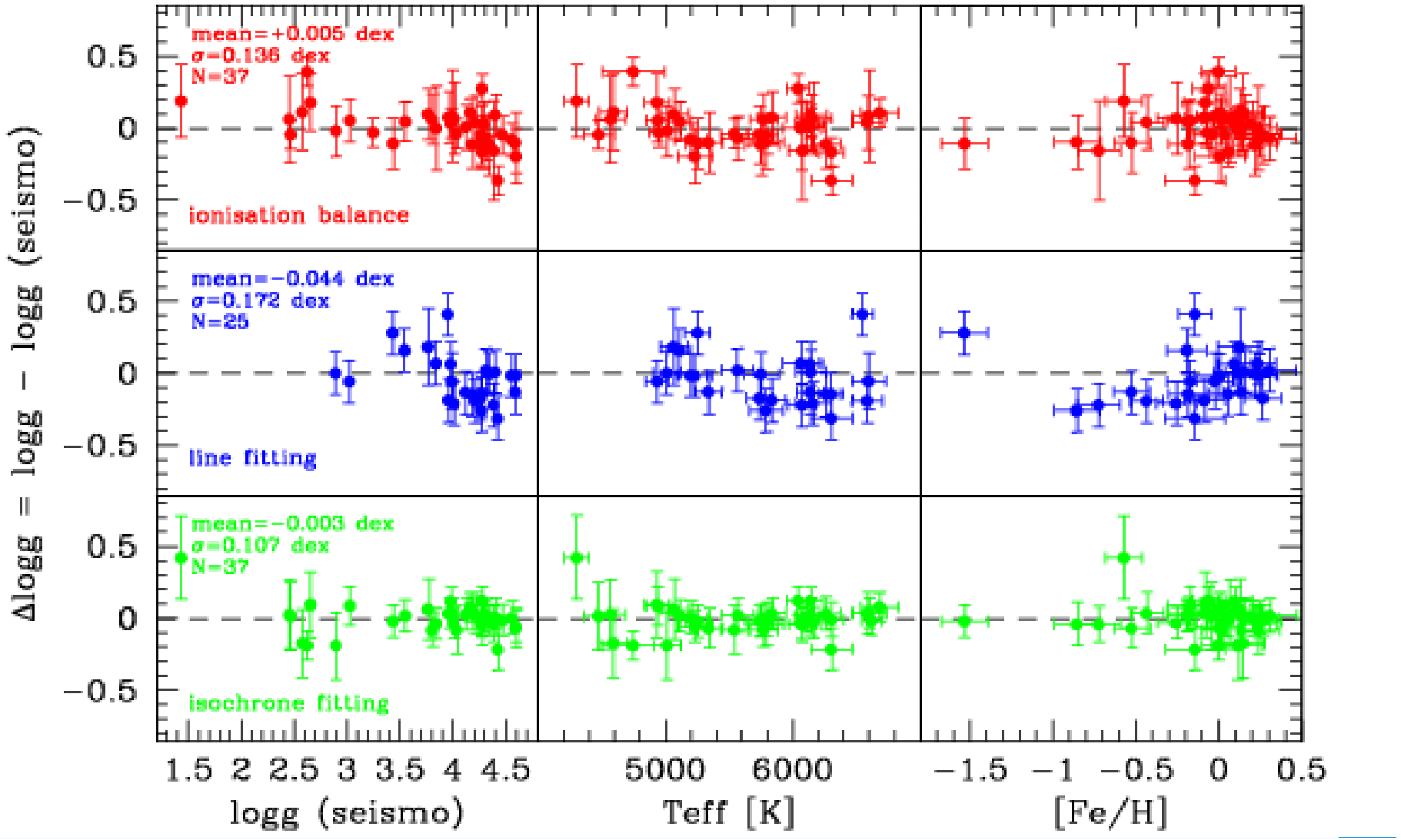
It is also possible to use other seismic observables (e.g., Δν) test.

All empirical tests carried out up to now suggest that the seismic gravities are precise and also likely accurate.

Example with Procyon A and α Cen A+B: seismic gravities and values based on dynamical masses and interferometric radii agree to within 0.02 dex.

Testing seismic gravities

About ~40 very bright dwarfs and giants have a surface gravity derived from high-quality asteroseismic data (Morel & Miglio 2012), compared with log(g) derived from different sources.



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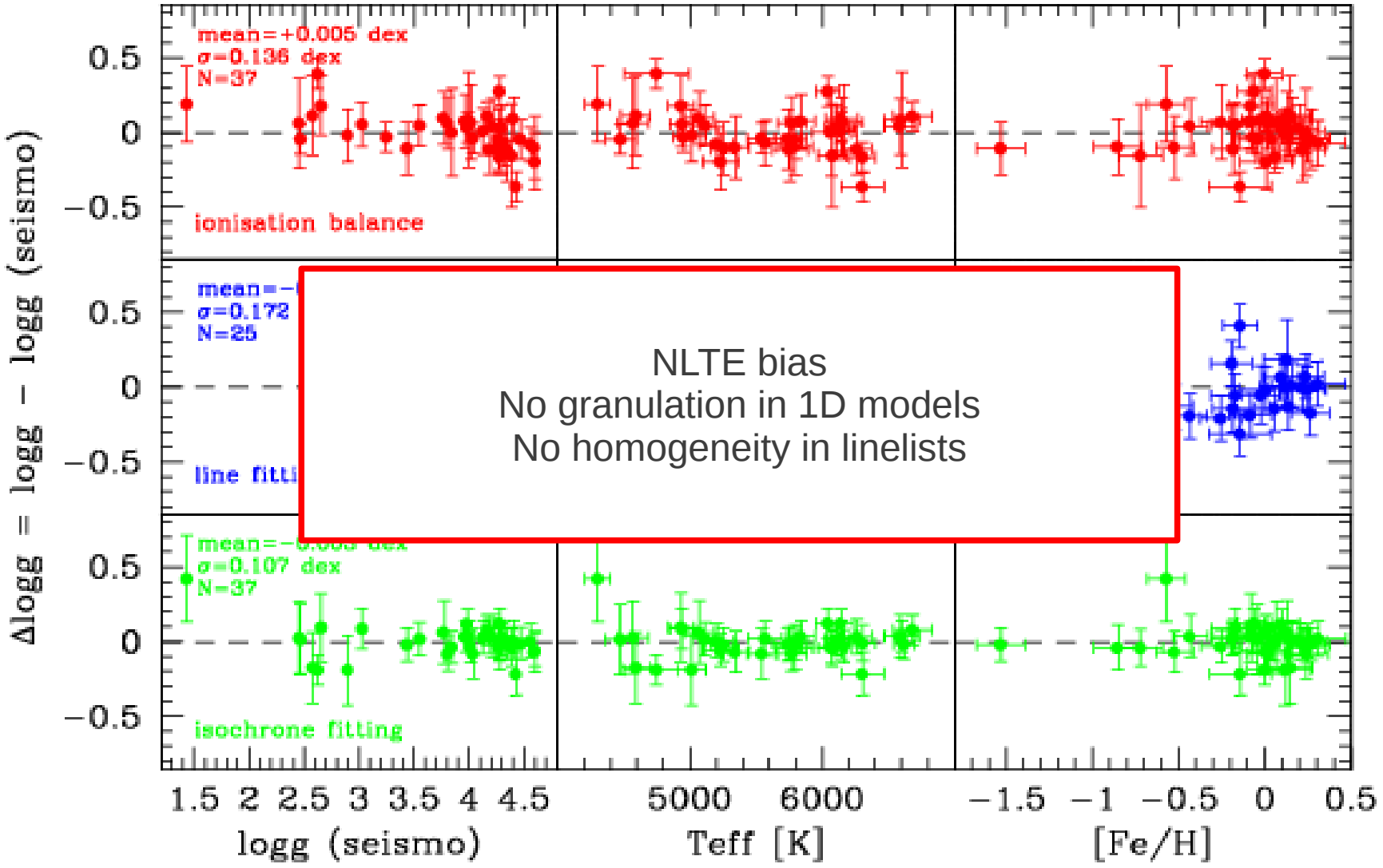

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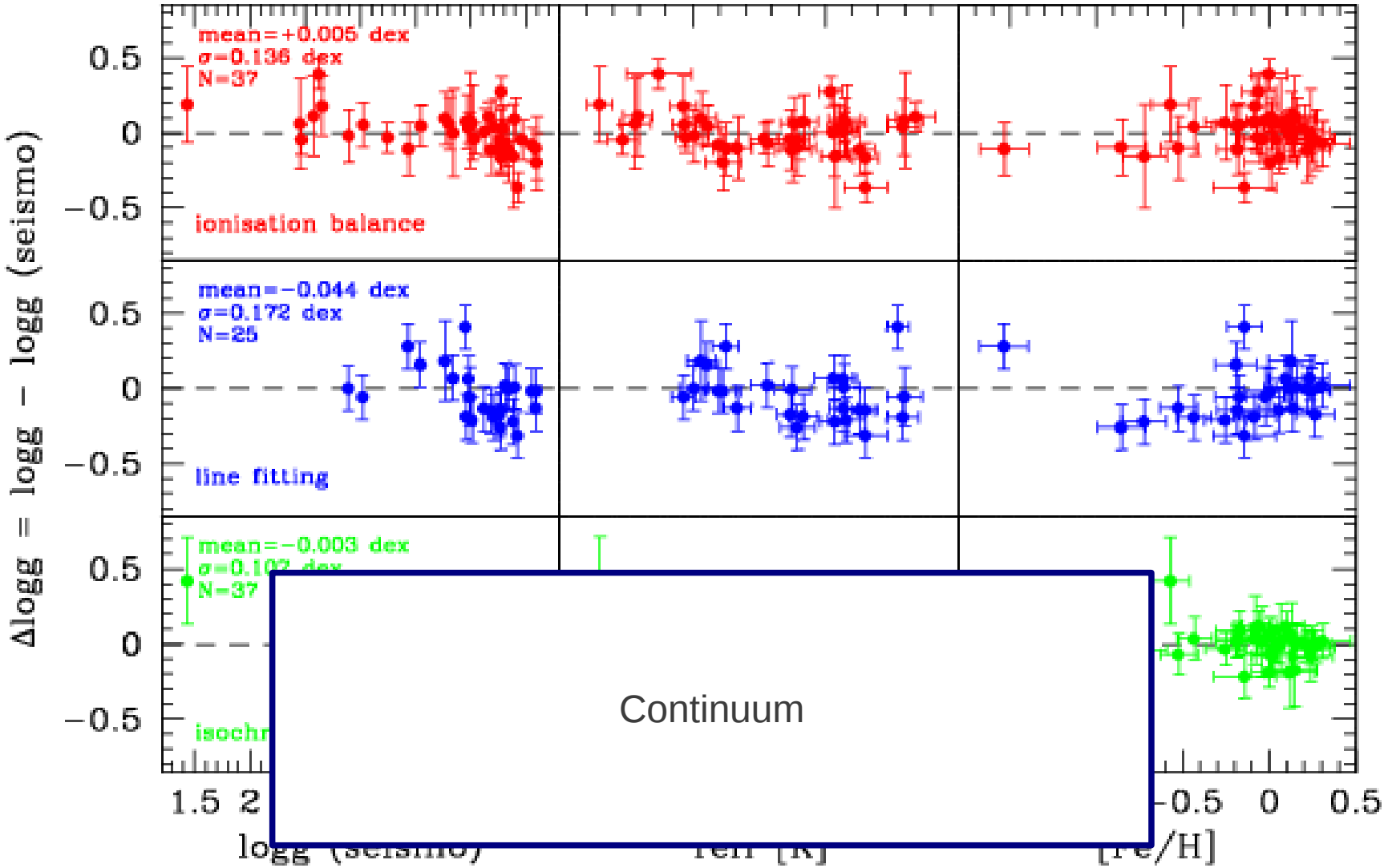

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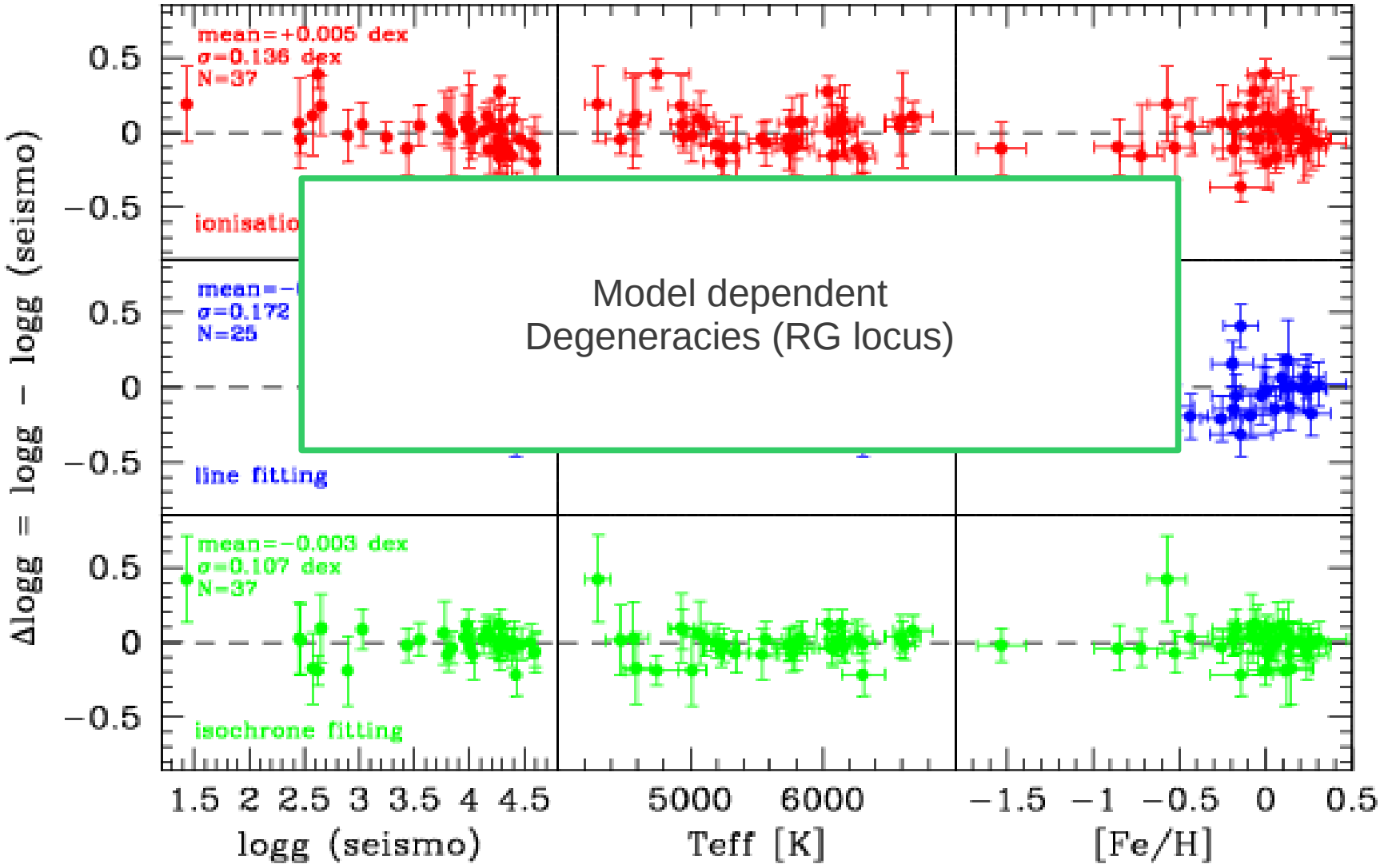


Seismic log(g)

May be worthwhile to consider seismic targets as benchmark stars in order to calibrate procedures: accurate gravities available for ~40 bright dwarfs and giants

(+ CoRoT field being observed).

Use of seismic gravities beginning to be implemented in abundance analyses

(e.g., Batalha et al. 2011; Thygesen et al., in prep.)

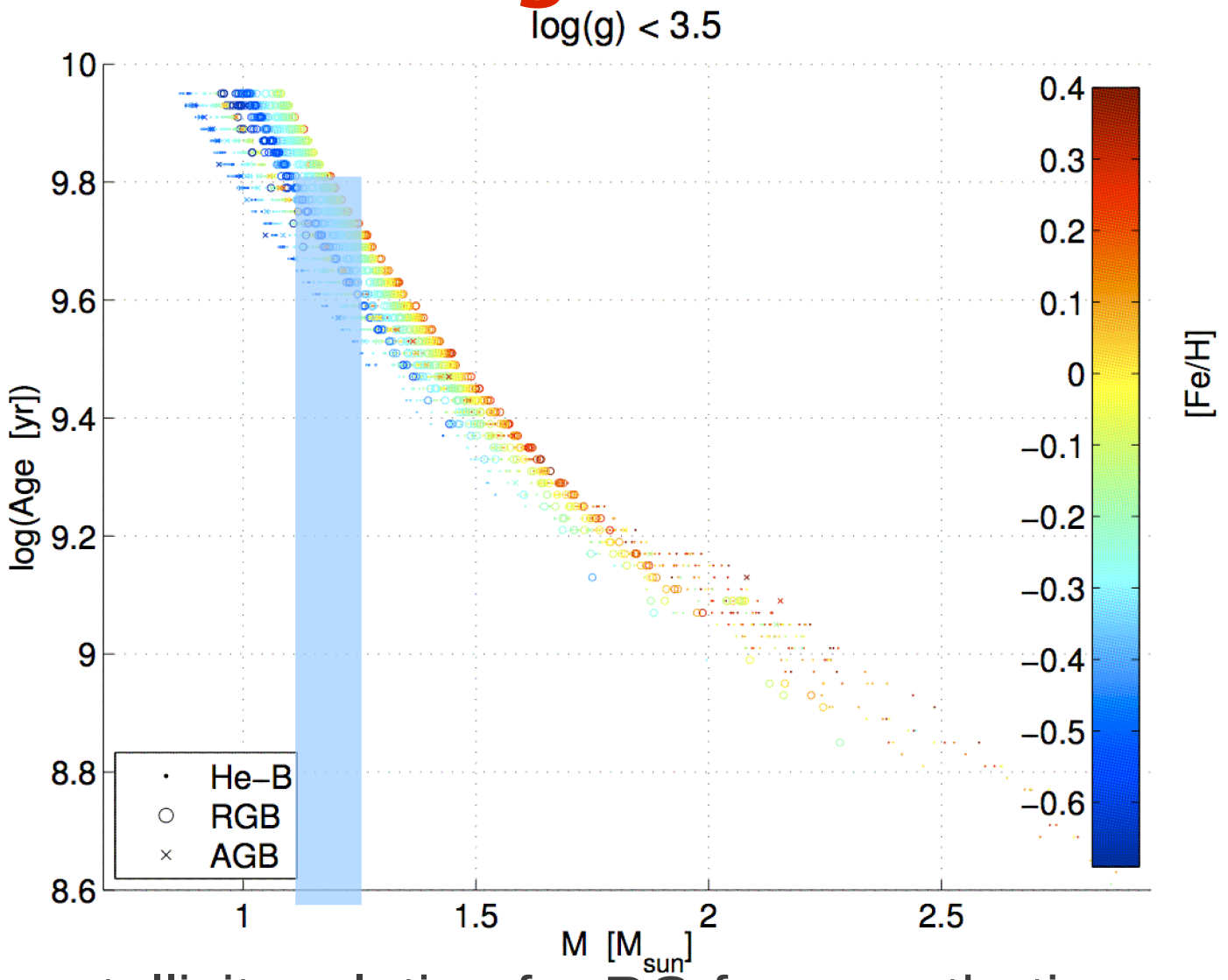
	Adopted	Seismic
Procyon	3.99±0.02	3.98±0.03
HD 49933	4.21±0.03	4.20±0.03
δ Eri	3.79±0.01	3.76±0.03
η Boo	3.80±0.02	3.83±0.03
β Hyi	3.98±0.02	3.95±0.03
α Cen A	4.31±0.02	4.33±0.03
α Cen B	4.54±0.02	4.54±0.03
τ Cet	4.44±0.02	4.58±0.03
18 Sco	4.43±0.01	4.45±0.03
μ Ara	4.27±0.02	4.25±0.03
β Vir	4.08±0.01	4.11±0.03
α Boo	1.59±0.04	1.42±0.03
ξ Hya	2.87±0.01	2.88±0.03

Ages and distances

Distances : by using the seismically determined mass and radius, and considering apparent magnitudes and reddening. Error of about 15%.

Ages: isochrone fitting, information on metallicity necessary to reduce error up to 30% for RG

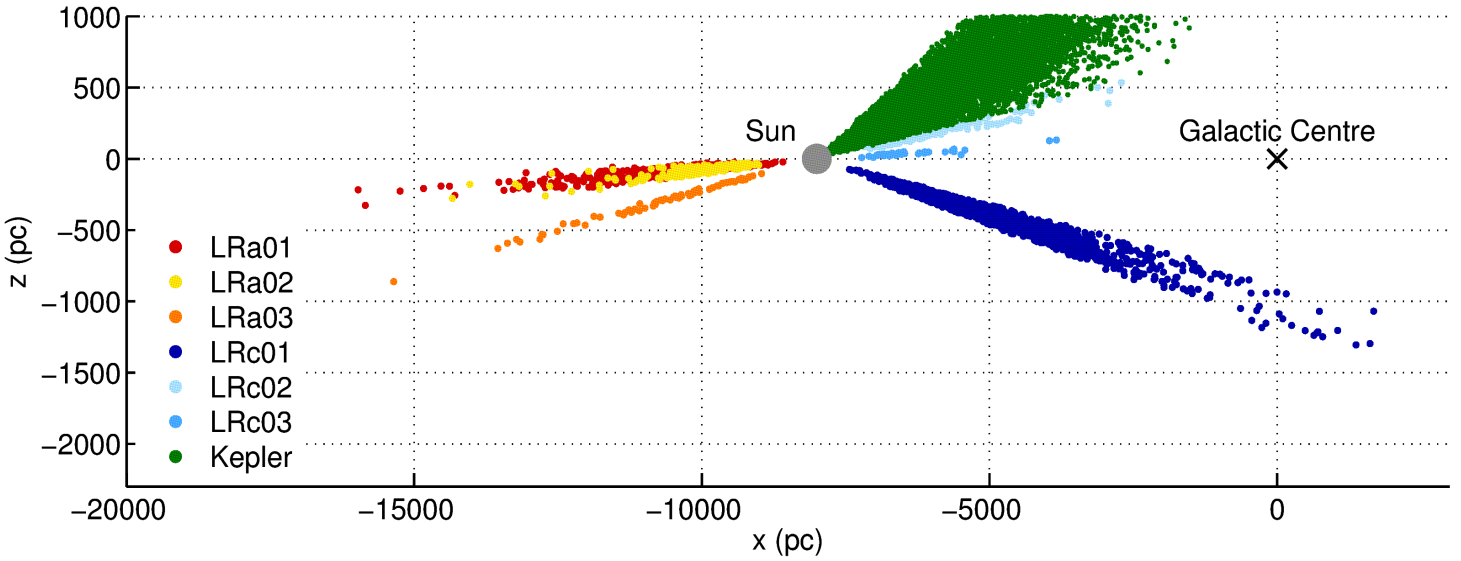
Ages

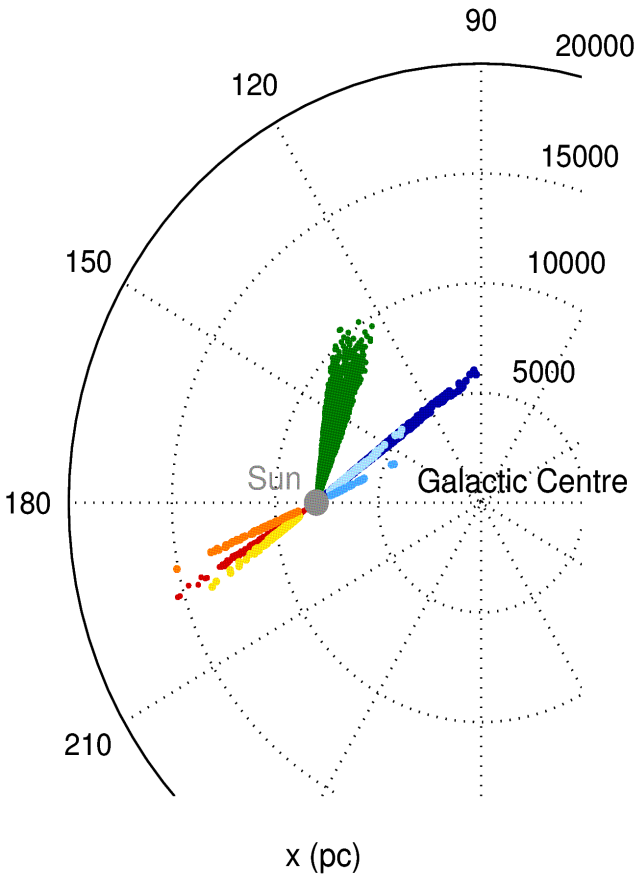


Age-mass-metallicity relation for RG for a synthetic population.

Corot fields

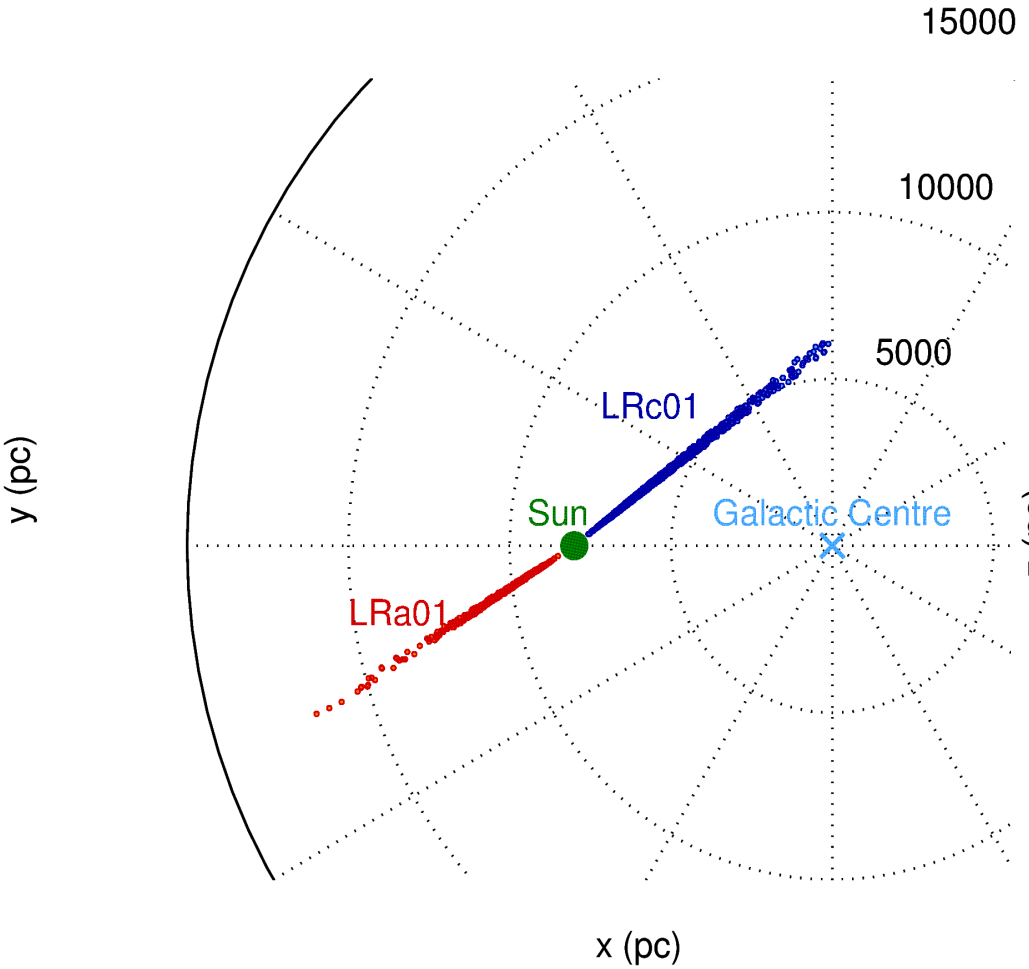
CoRoT satellite detected solar-like oscillations in thousands of Red Giants. 1

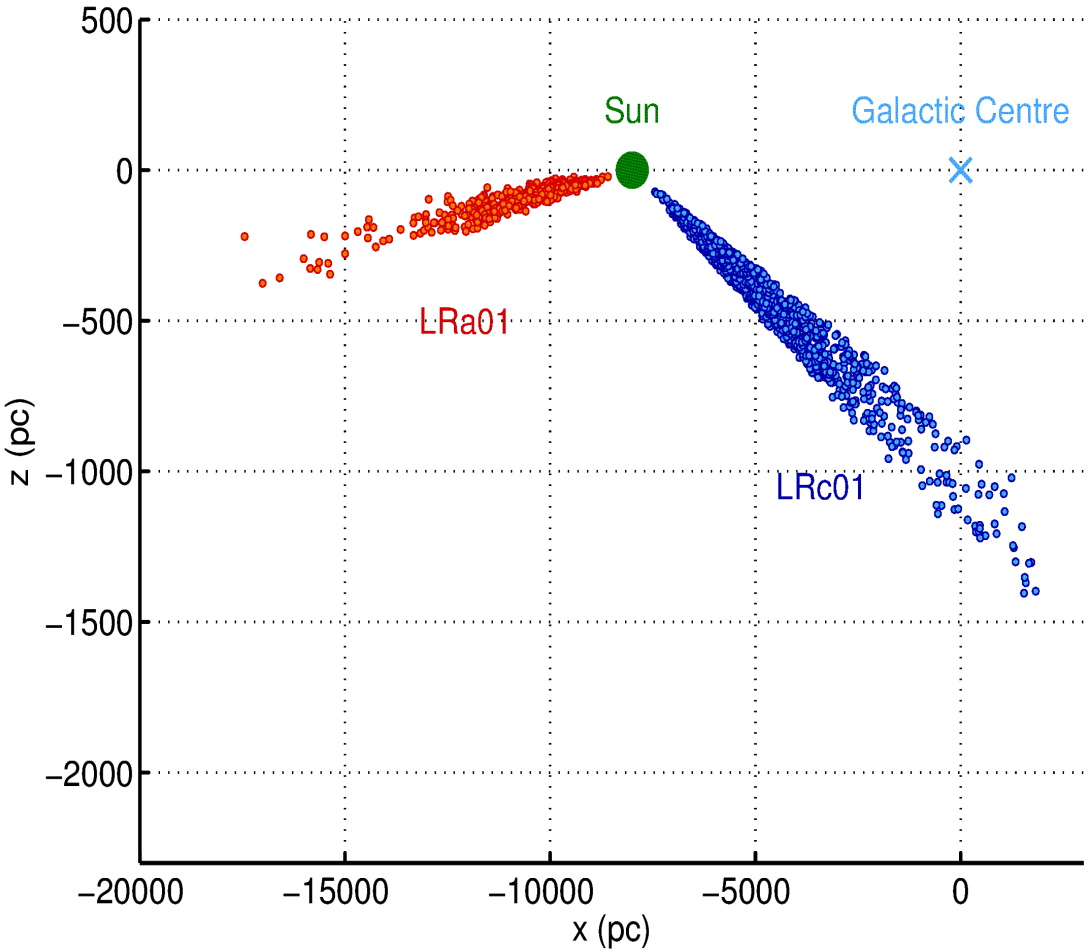




Miglio et al. (2012)

CoRoT LRa01 and LRc01

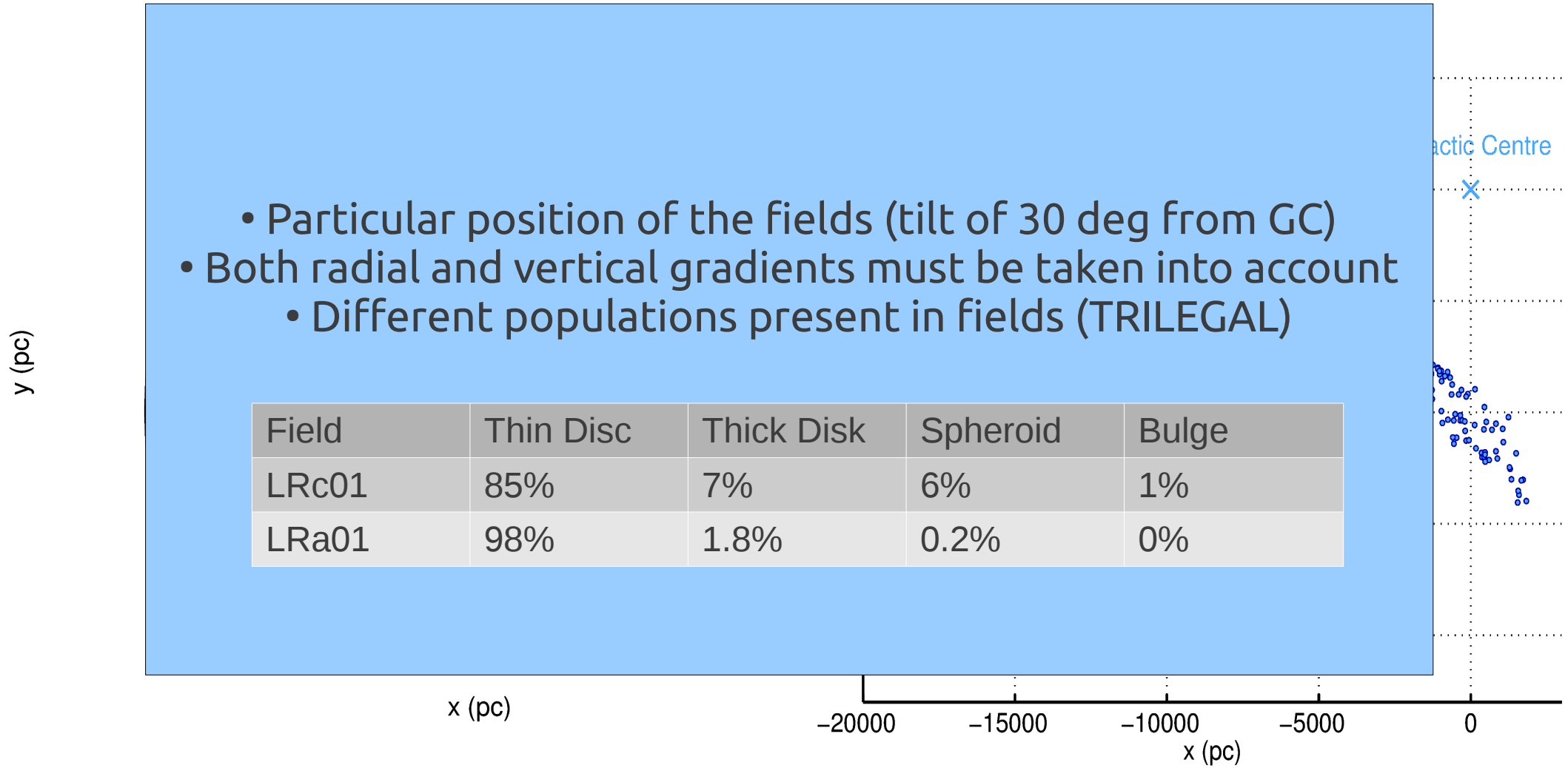




CoRoT LRa01 and LRc02: a small test

- Particular position of the fields (tilt of 30 deg from GC)
- Both radial and vertical gradients must be taken into account
- Different populations present in fields (TRILEGAL)

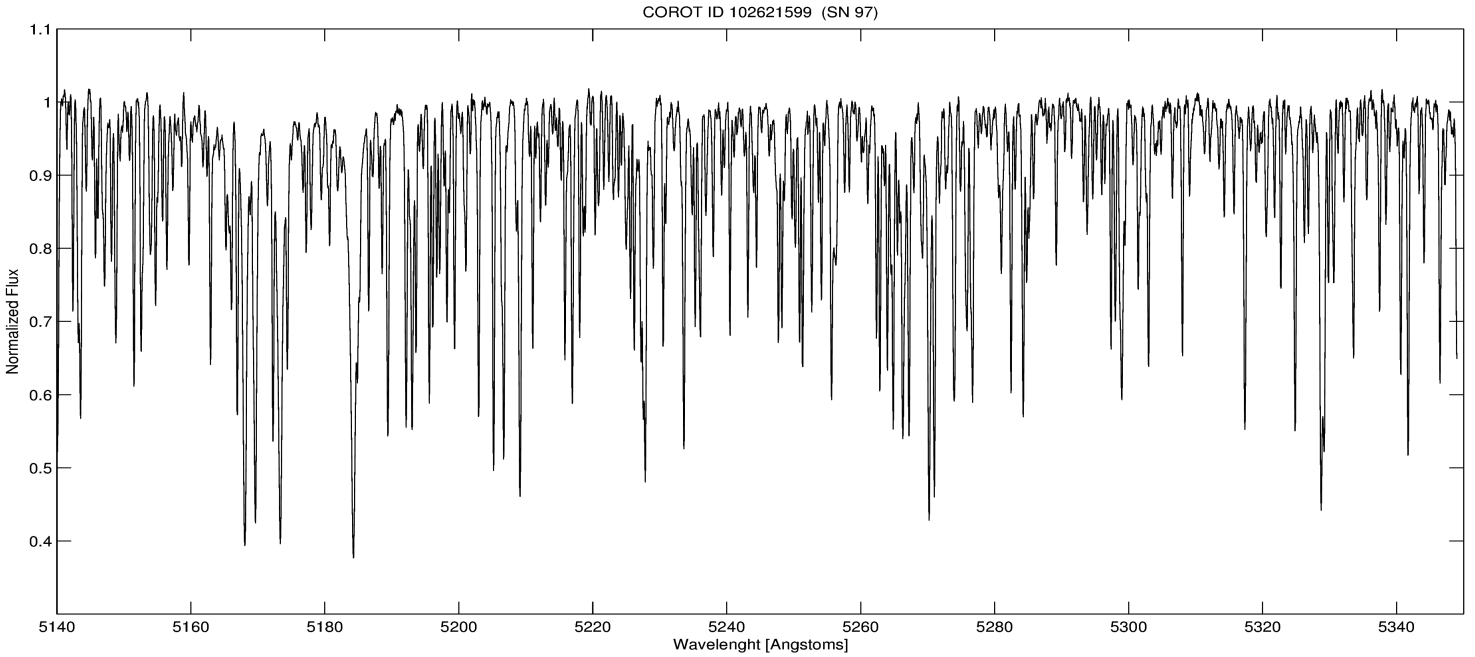
Field	Thin Disc	Thick Disk	Spheroid	Bulge
LRc01	85%	7%	6%	1%
LRa01	98%	1.8%	0.2%	0%



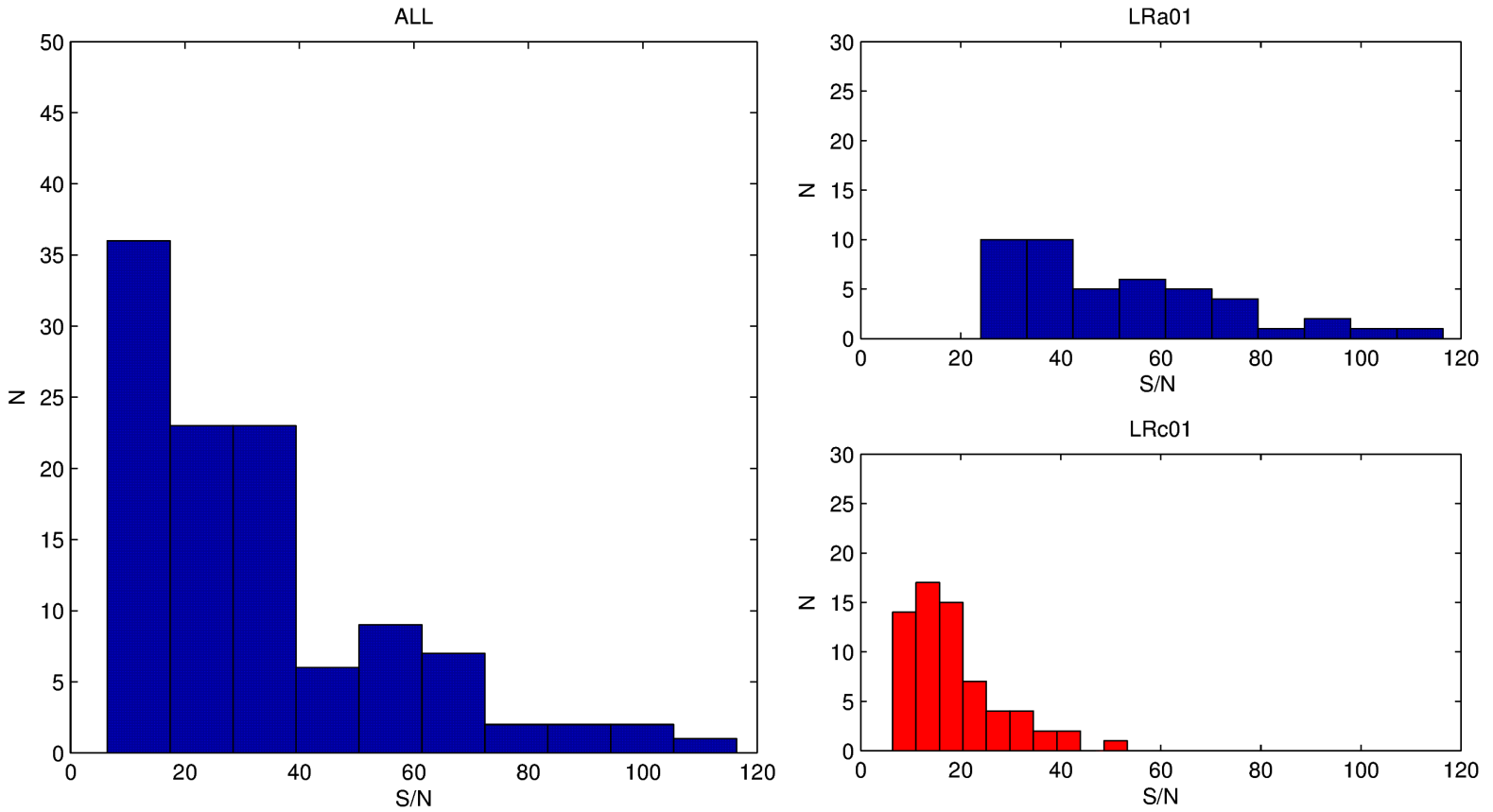
CoRoT LRa01 and LRc02: a small test

111 objects already observed RG (Gazzano et al 2010)

GIRAFFE HR9 (5278 AA, 200 AA)

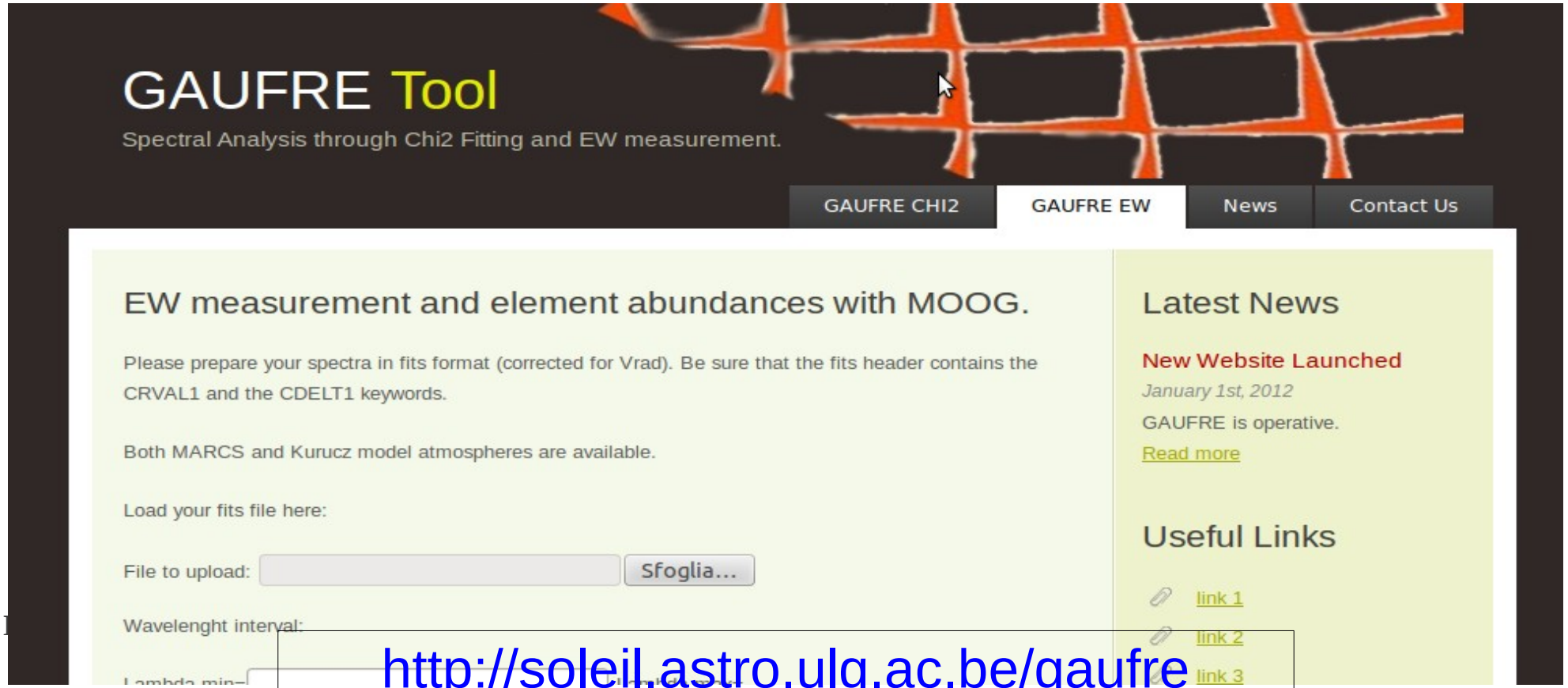


CoRoT LRa01 and LRc02: a small test



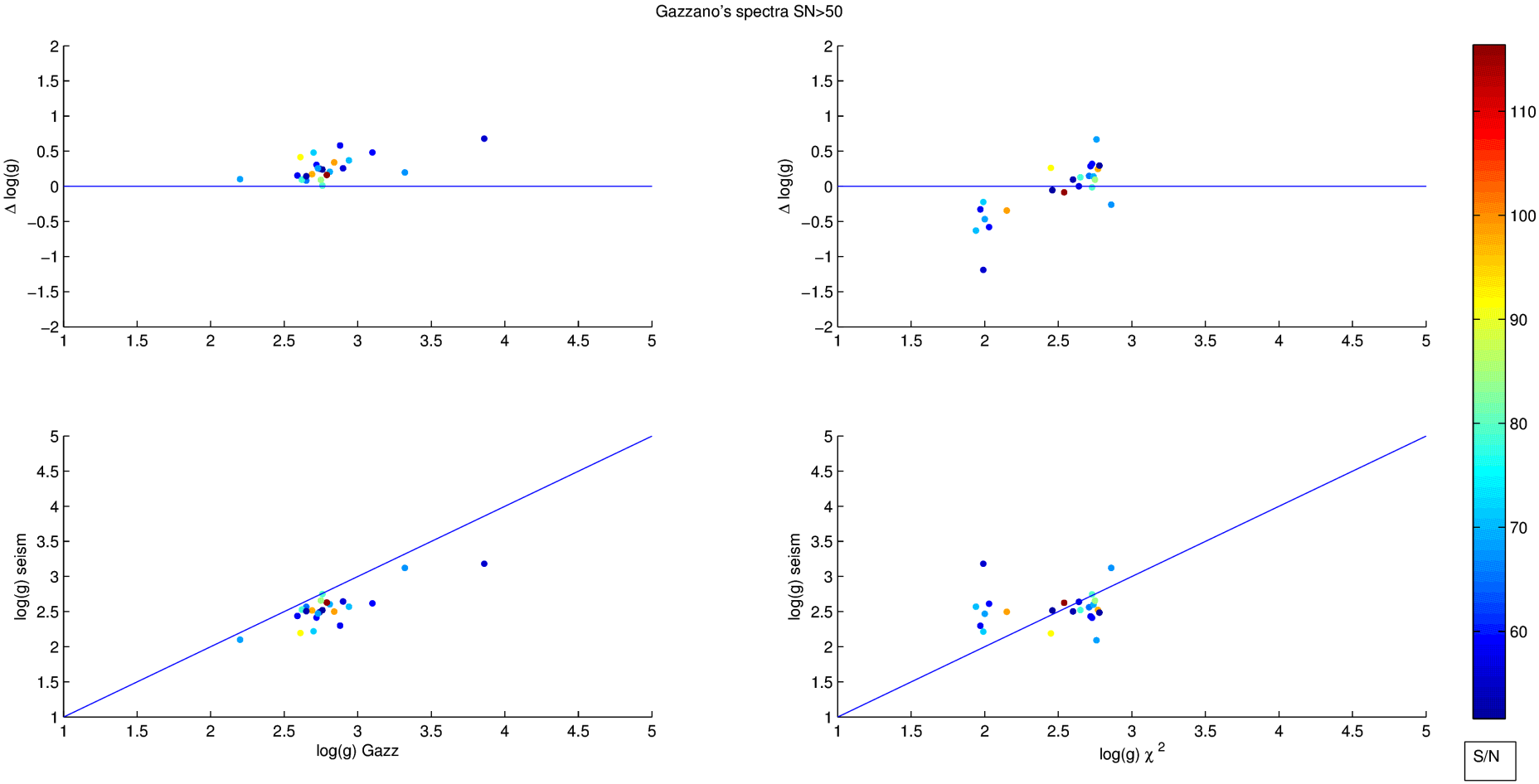
GAUFRE tool

- Chi2 fitting against a library of synthetic spectra
- EW+MOOG
- Possibility of fixing log(g) to the seismic value



http://soleil.astro.ulg.ac.be/gaufre

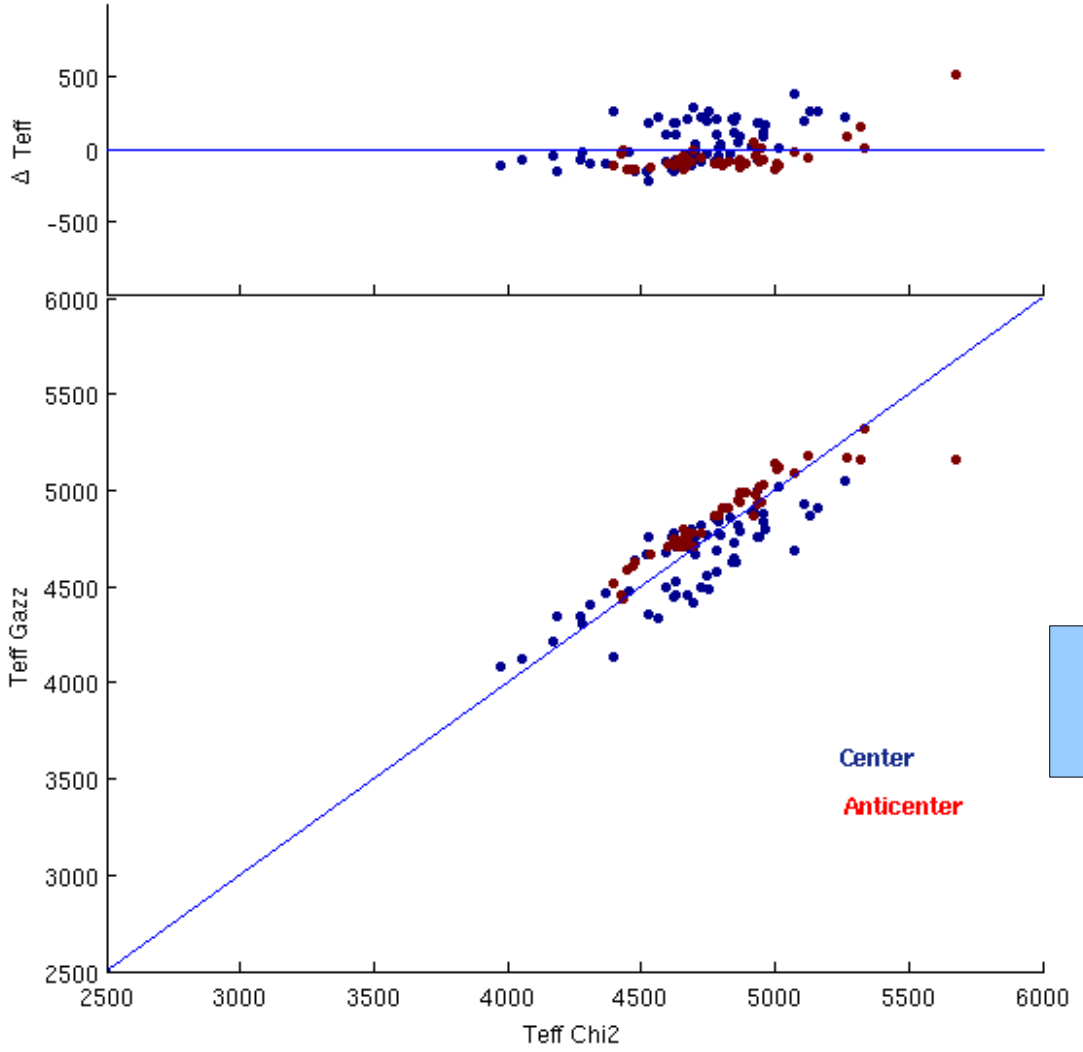
CoRoT LRa01 and LRc01: a small test



SNR>50

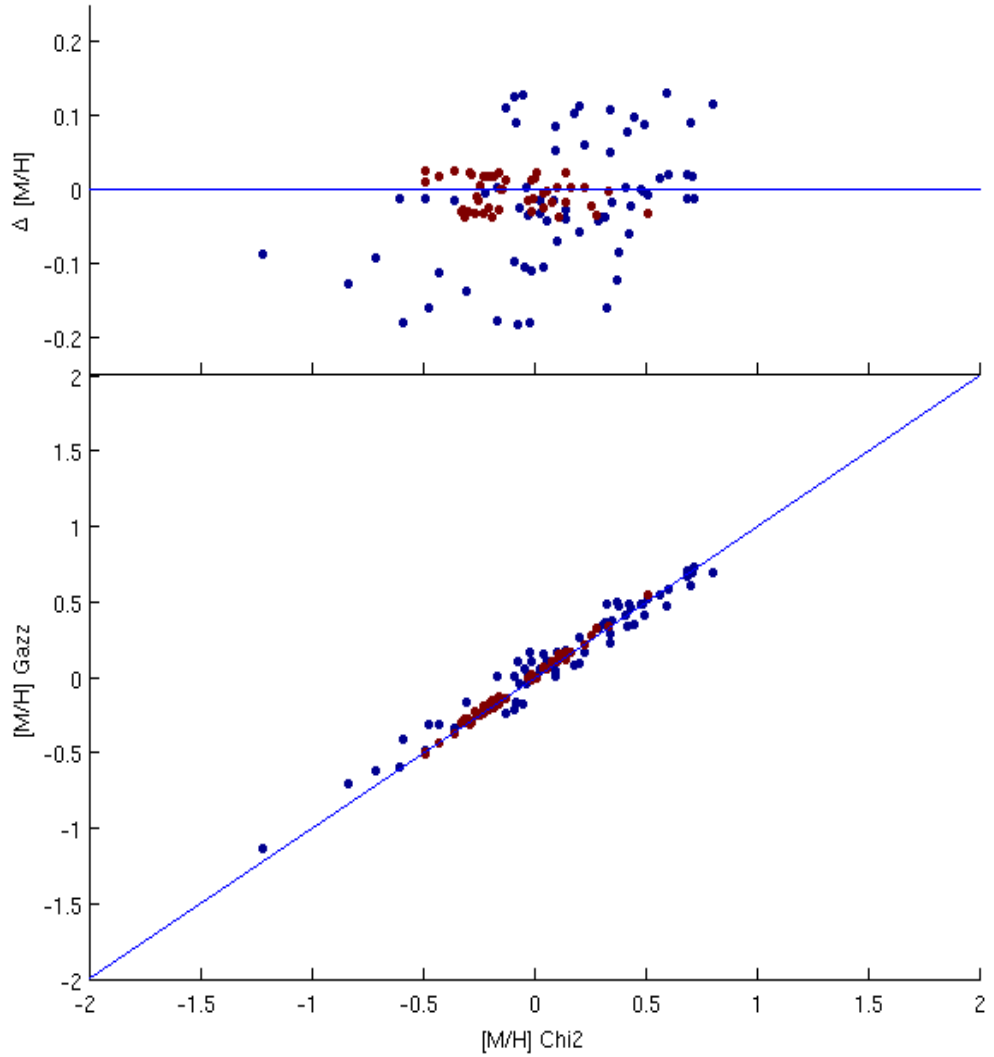
σ_log(G)=0.2 dex

CoRoT LRa01 and LRc02: a small test



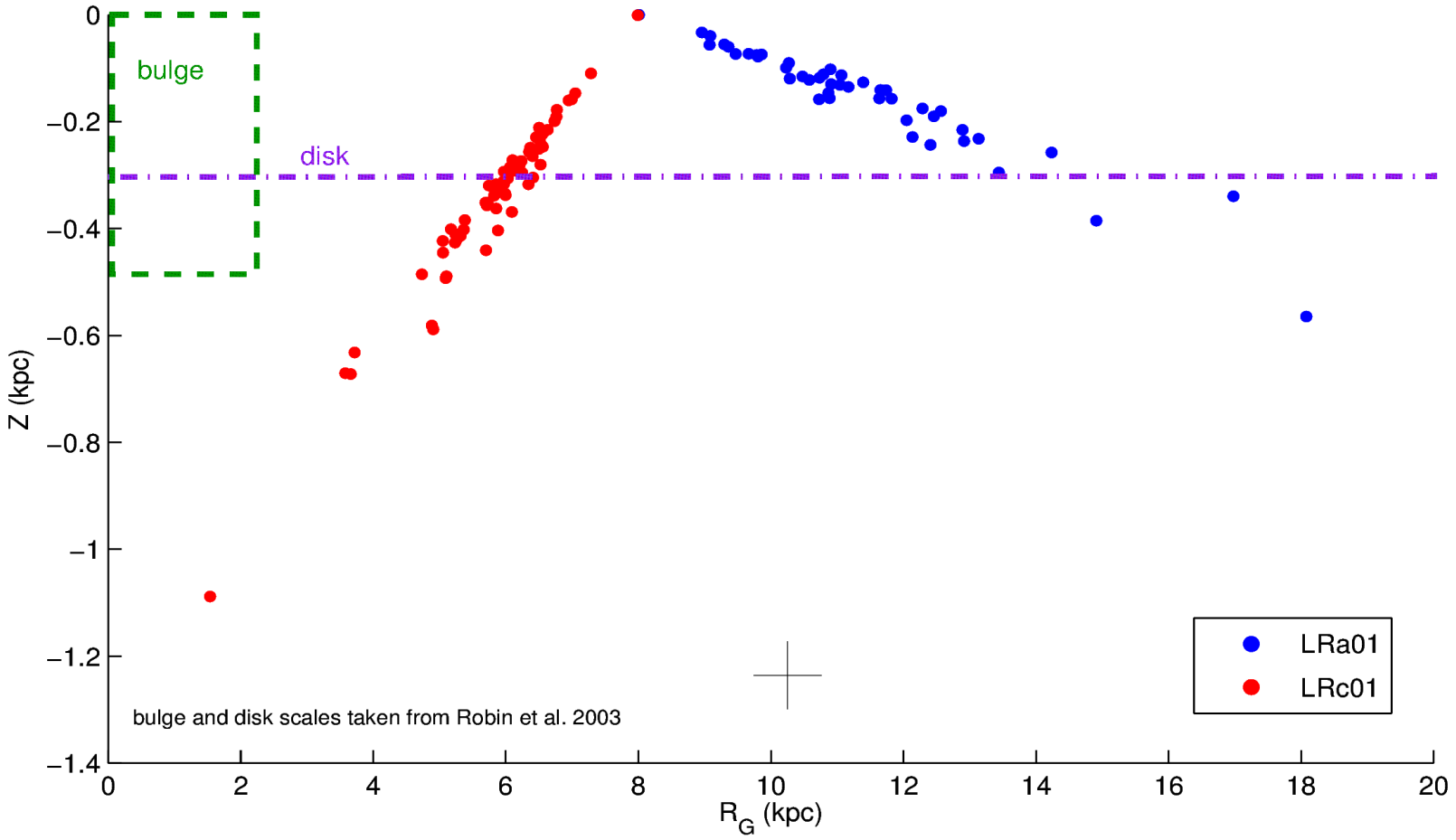
σ_Teff=74 K

CoRoT LRa01 and LRc01: a small test

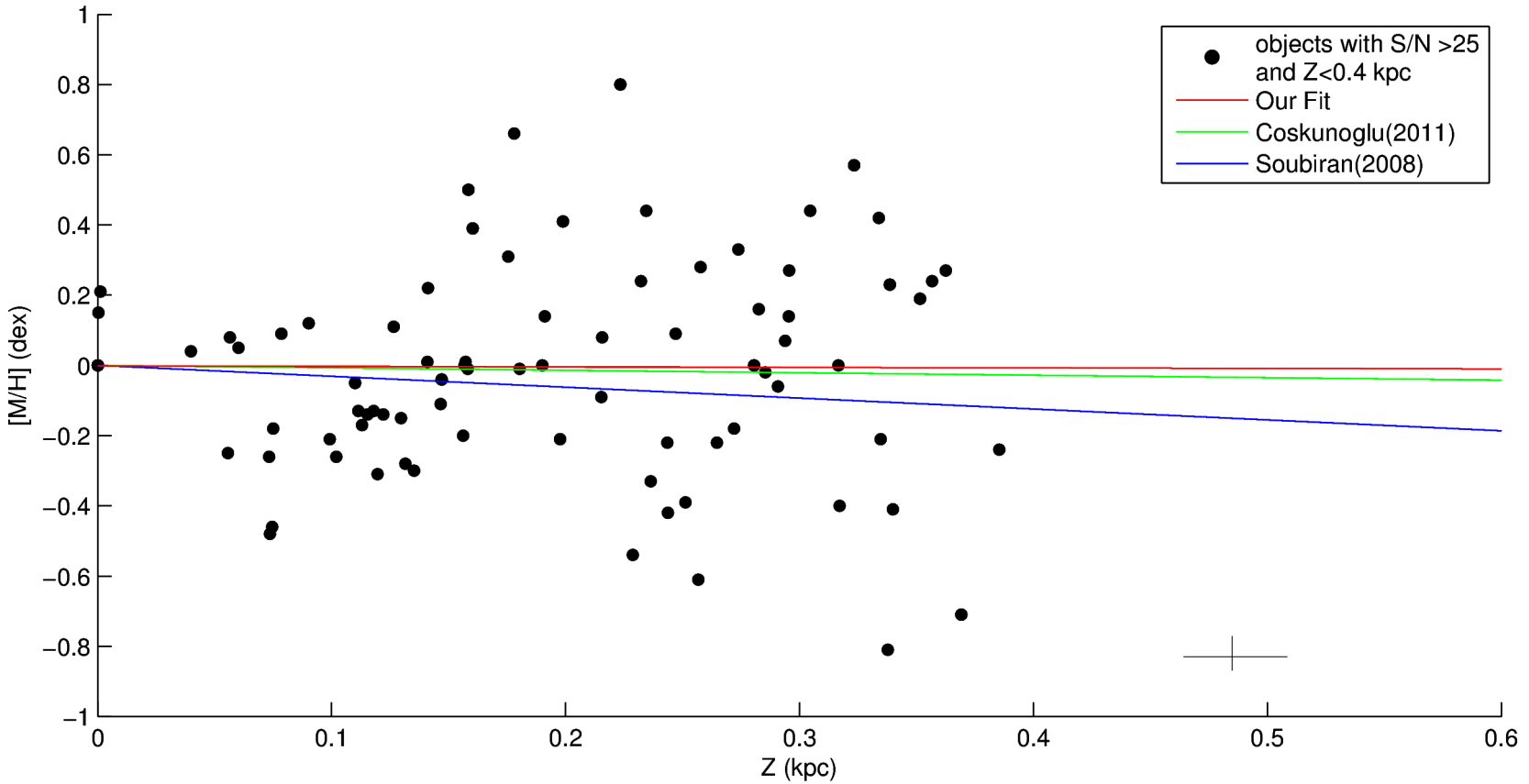


σ_[M/H]=0.08 dex

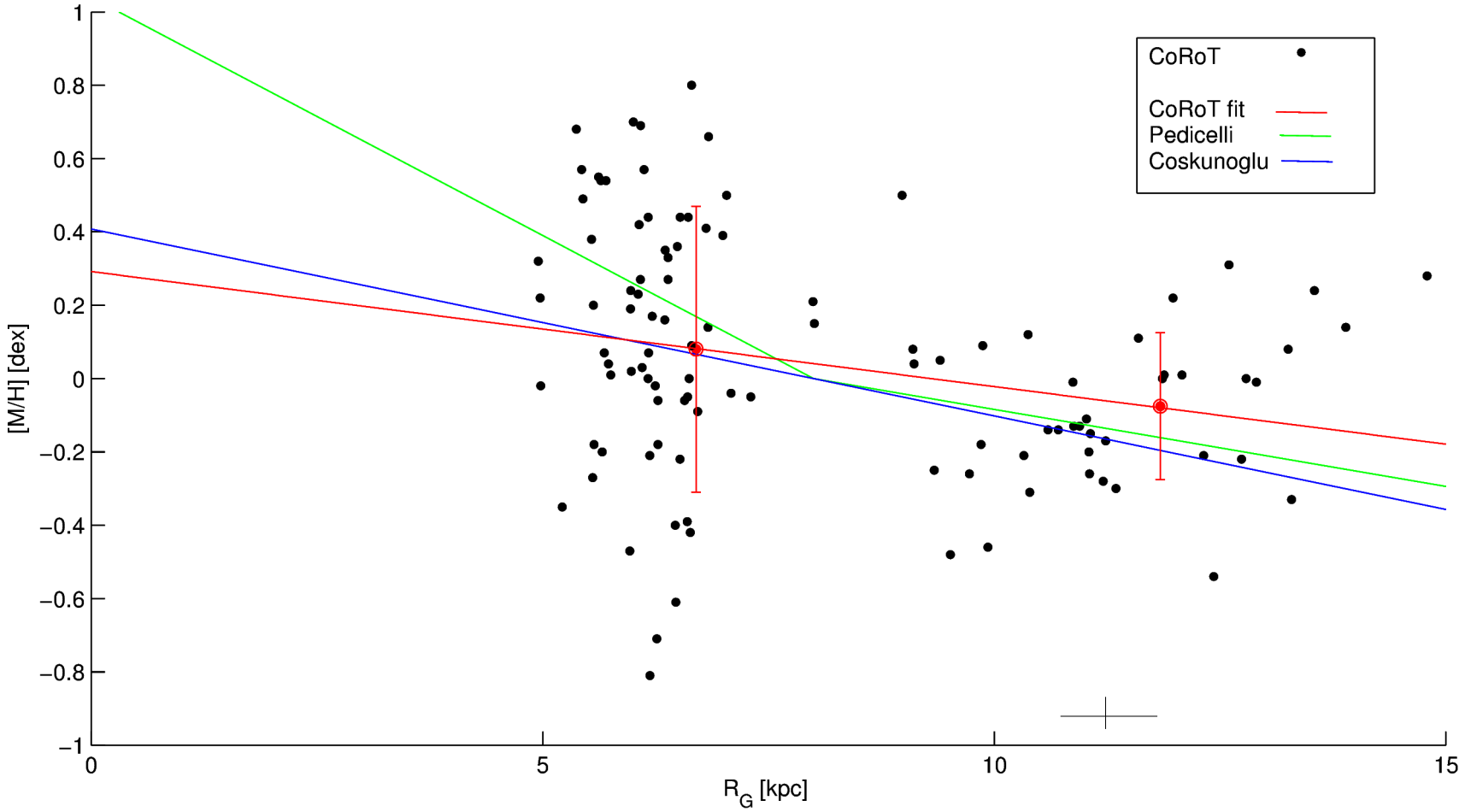
CoRoT LRa01 and LRc01: a small test



CoRoT LRa01 and LRc01: a small test

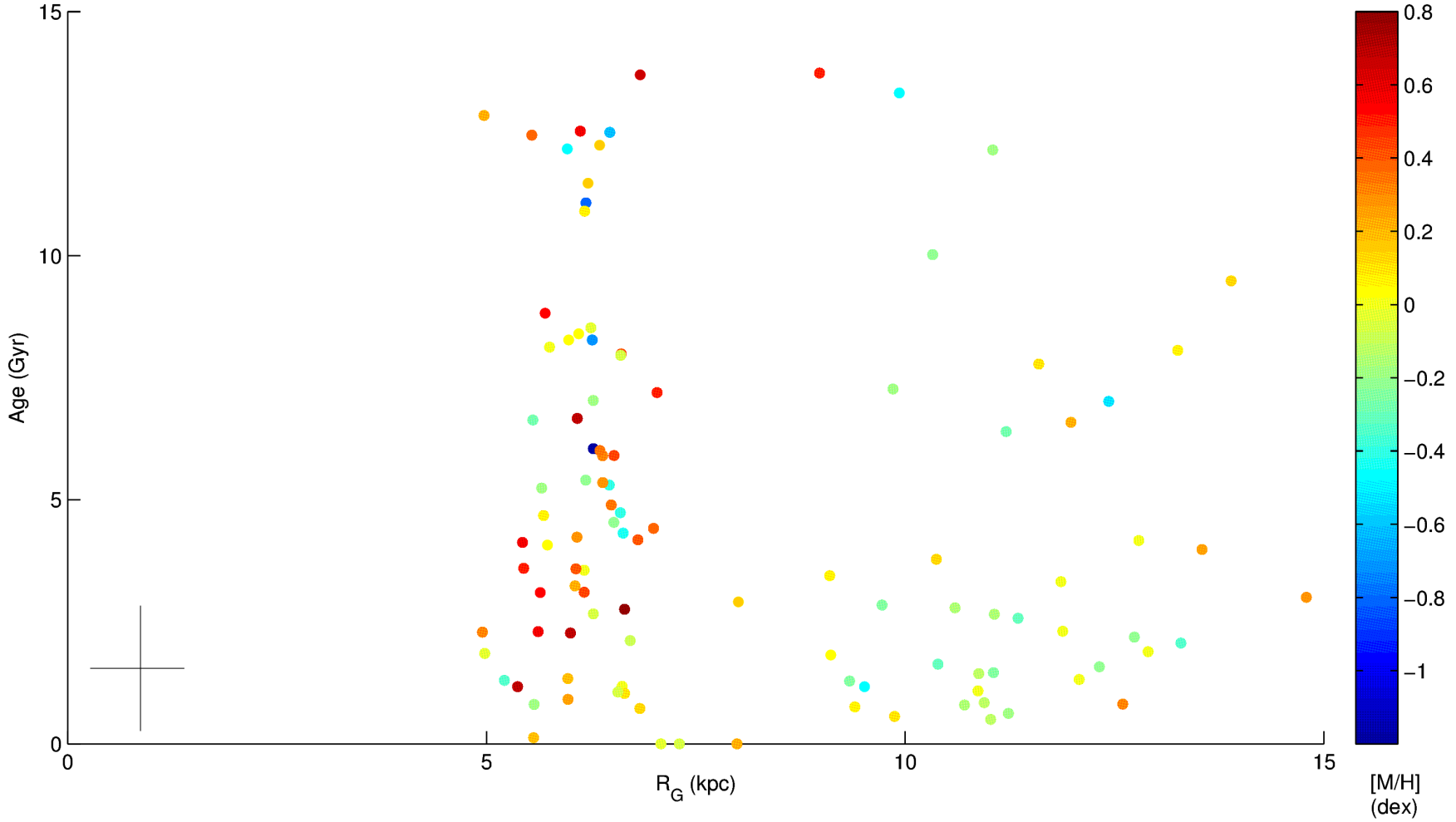


CoRoT LRa01 and LRc01: a small test



d[M/H]/dR=-0.031 dex/kpc

CoRoT LRa01 and LRc01: a small test



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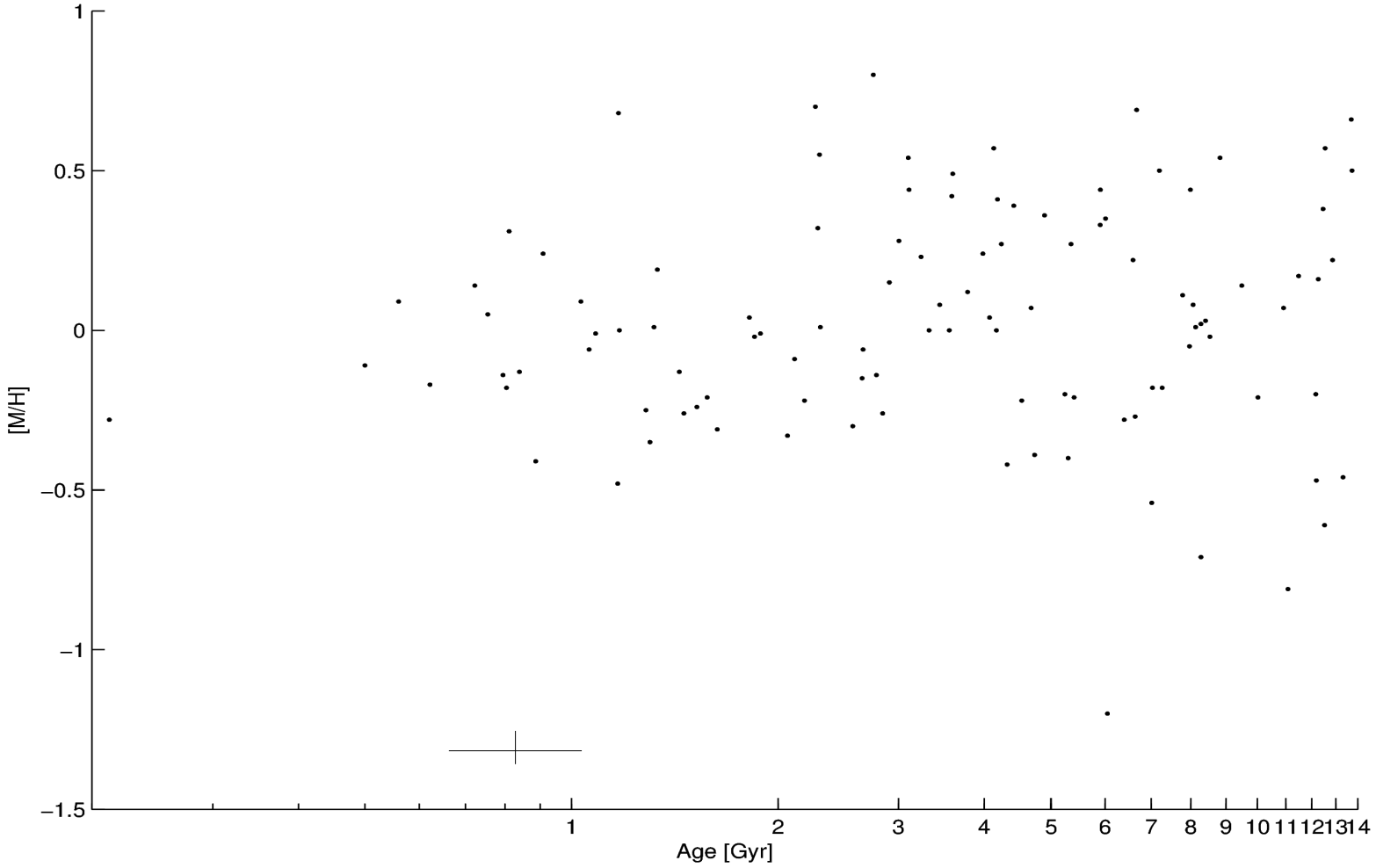


CoRoT LRa01 and LRc01: a small test

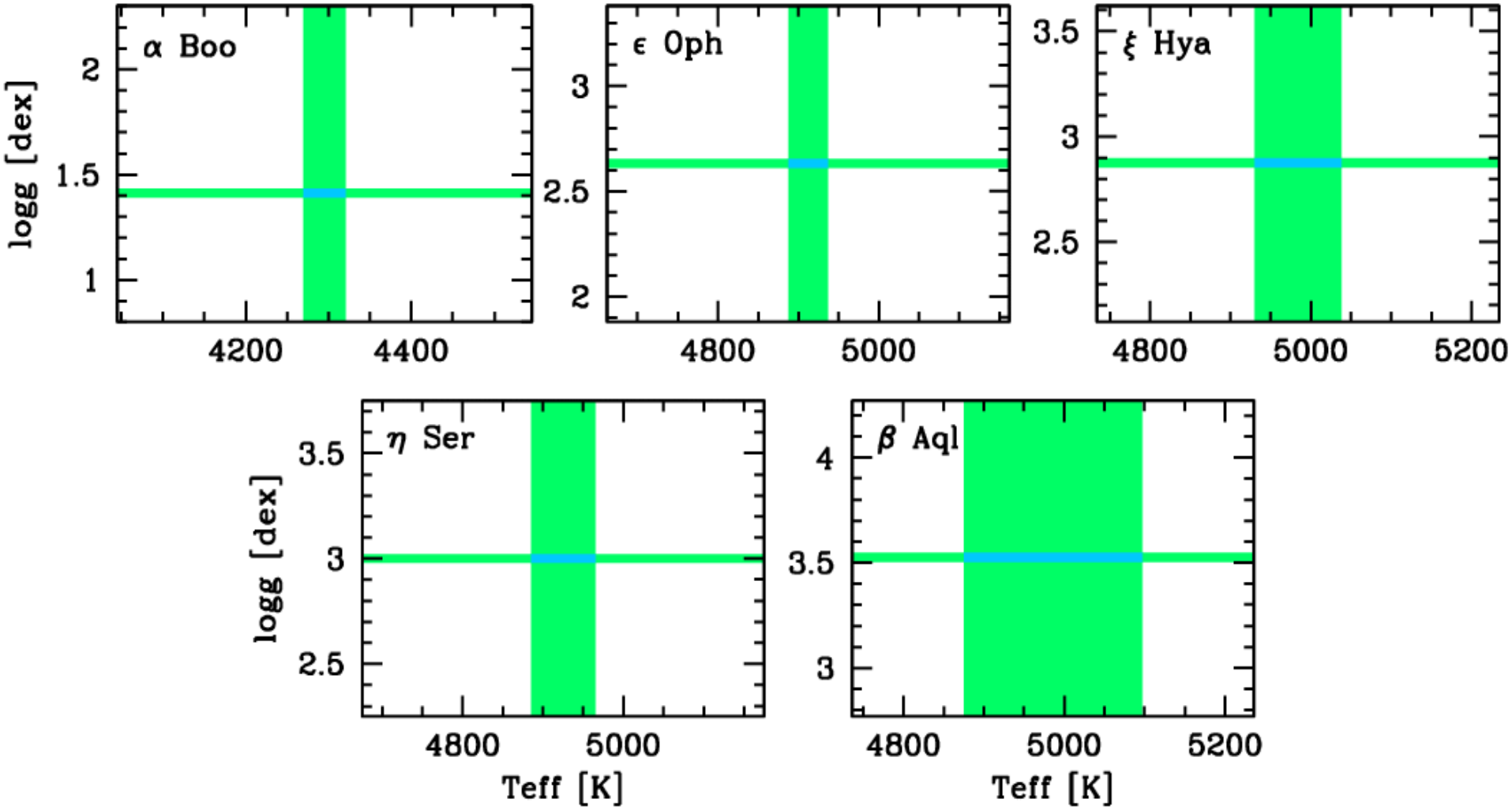
Fields characteristics:

Field	[M/H]	Disp.	Age	Disp.	[α/Fe]	Disp
LRa01	0.09	0.39	5.39	3.8	0.08	0.04
LRc01	-0.12	0.22	3.75	3.9	0.08	0.06

Conclusions

- Asteroseismology trustworthy instr. for log(g)
- Testing scaling relation in in different places of HR diagram and different [Fe/H]
- CoRoT fields need to be observed: chemical patterns, gradients, etc.
- GES already collected spectra for Corot stars (about 20 RG with GIRAFFE, 2 with UVES)

Manual method validated using red giants with 'direct' (i.e., nearly model independent) parameter estimates: Teff from interferometry and logg from asteroseismology



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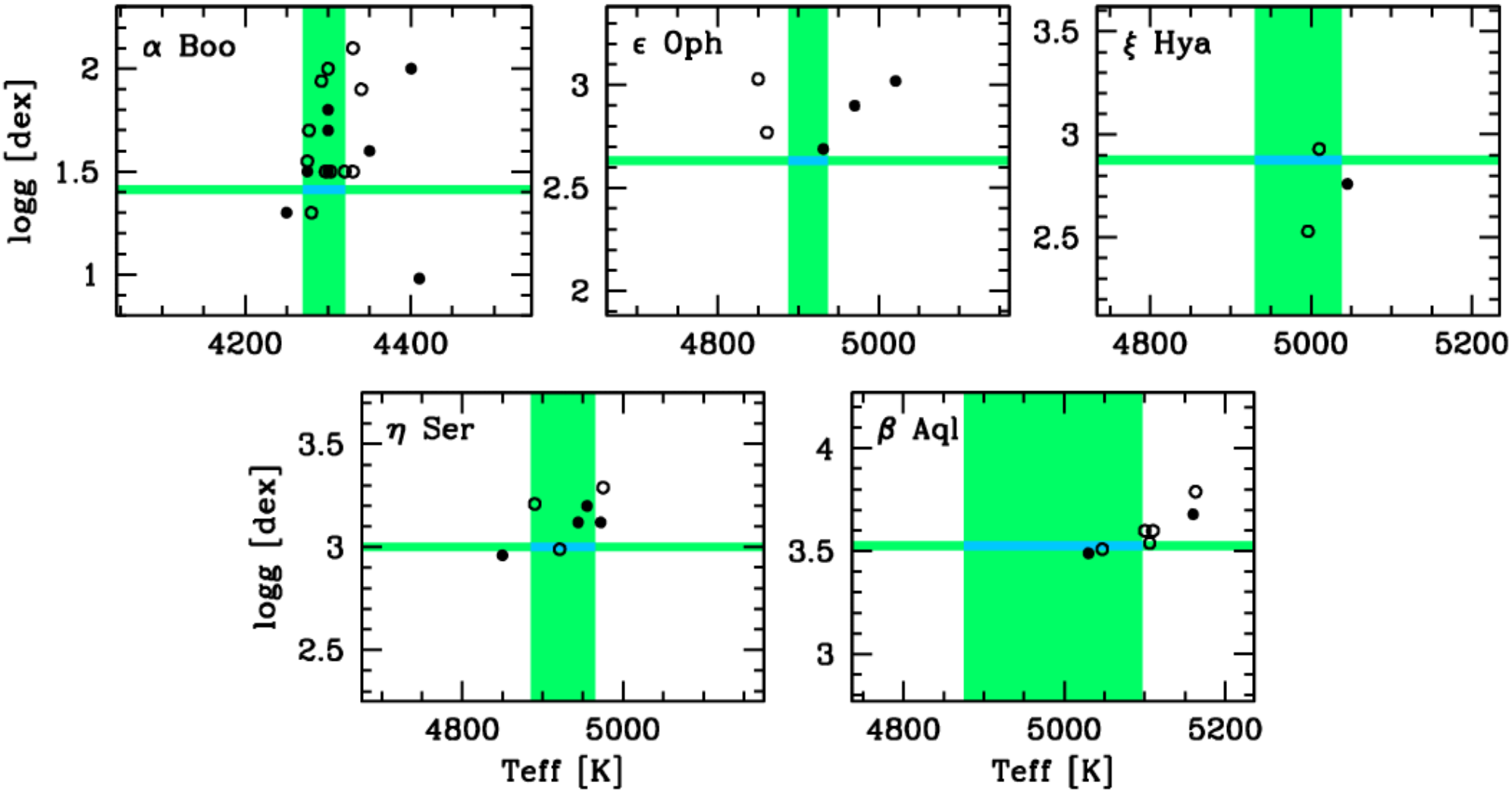

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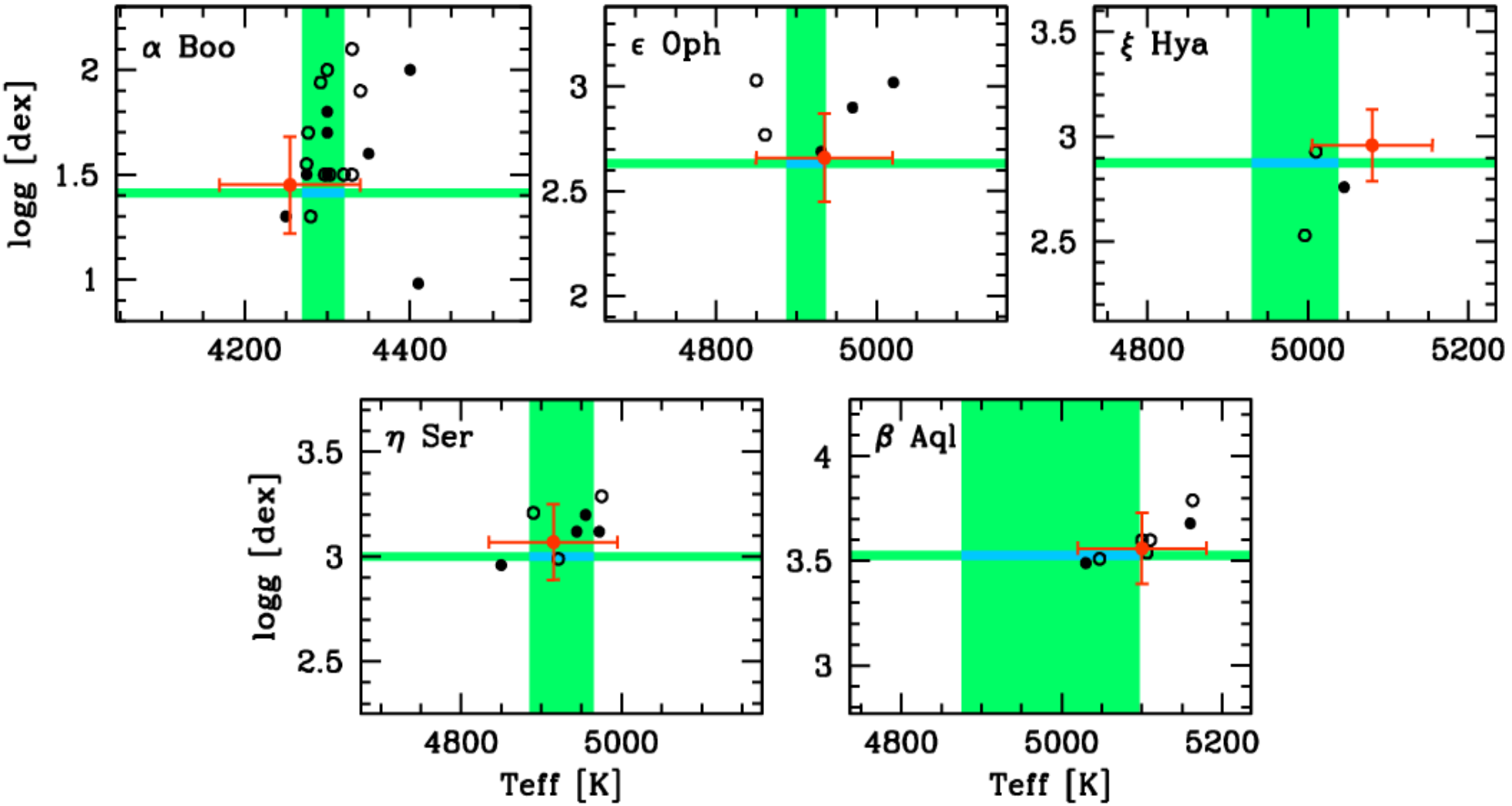
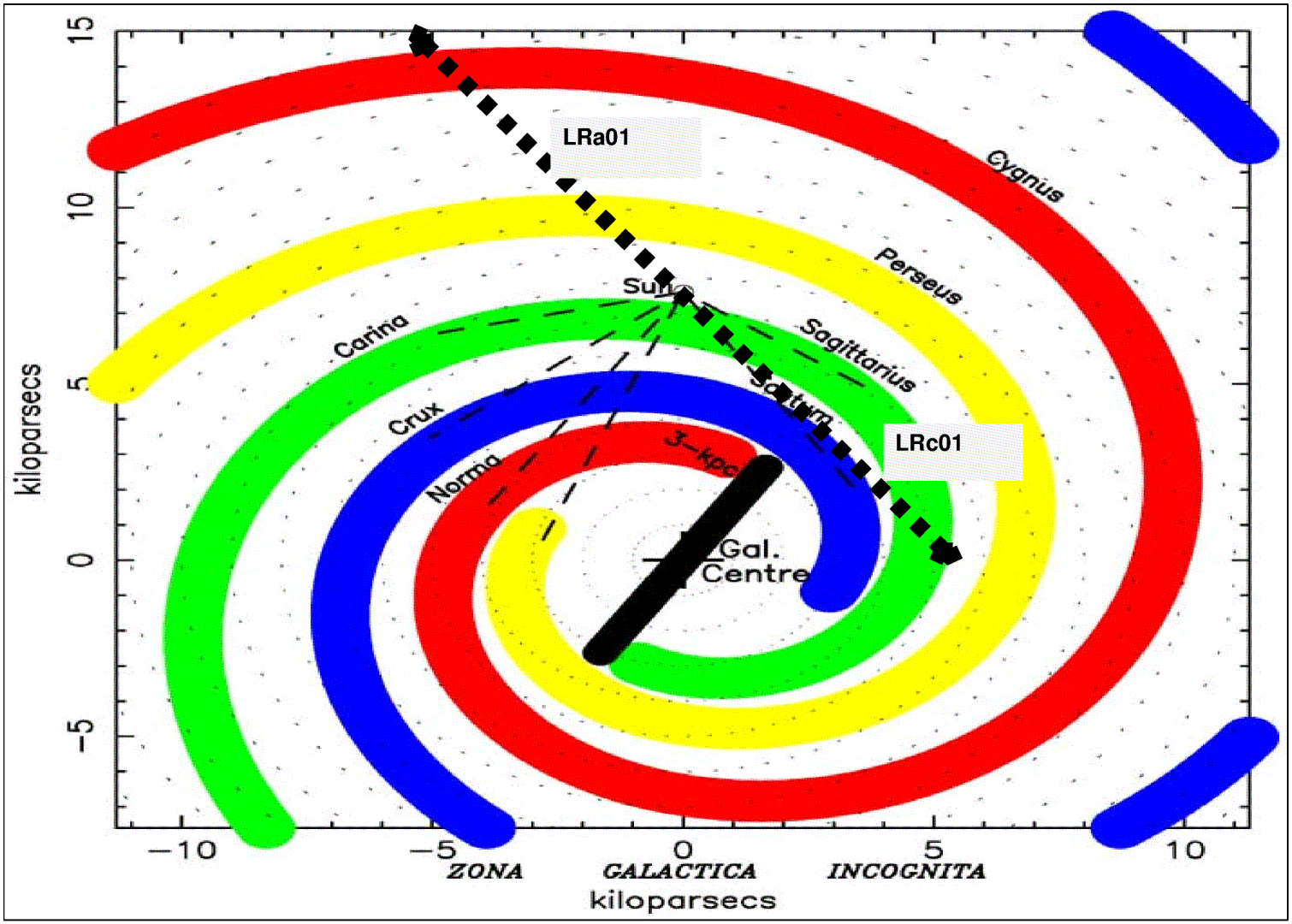
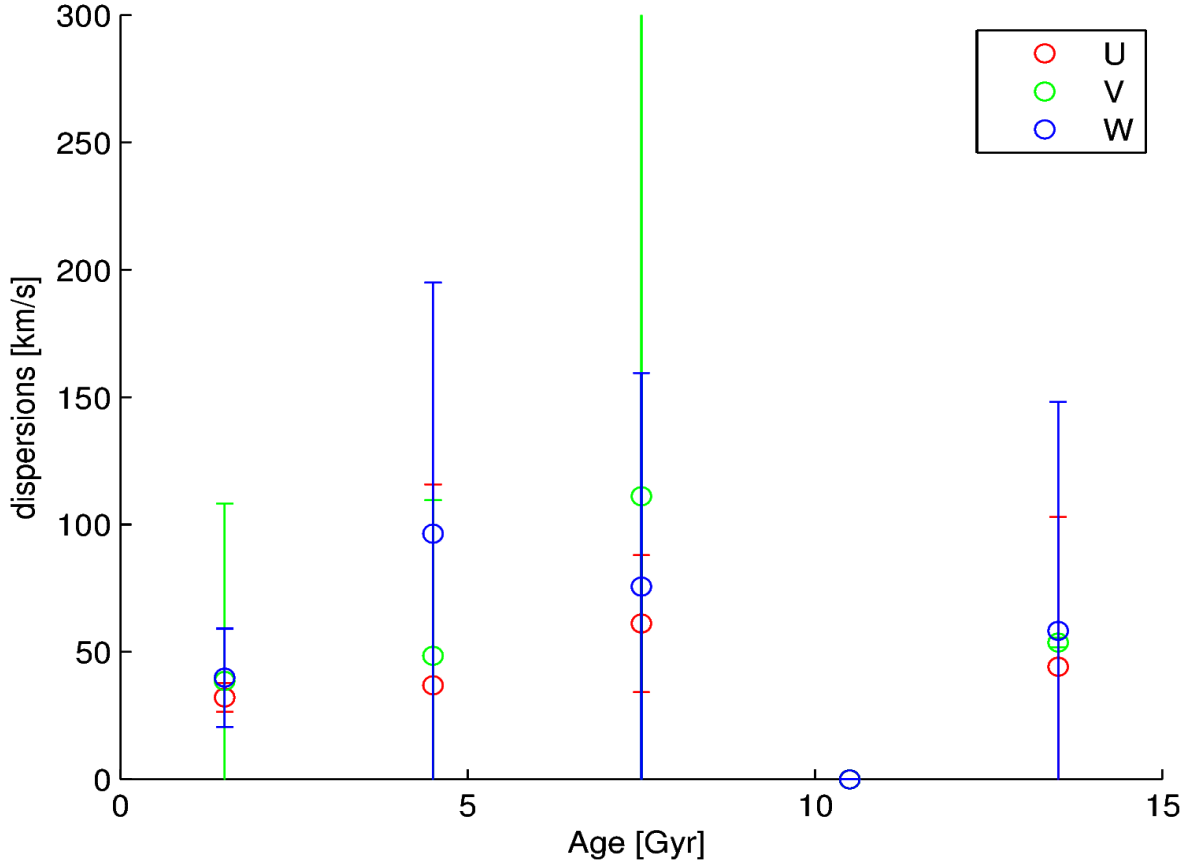
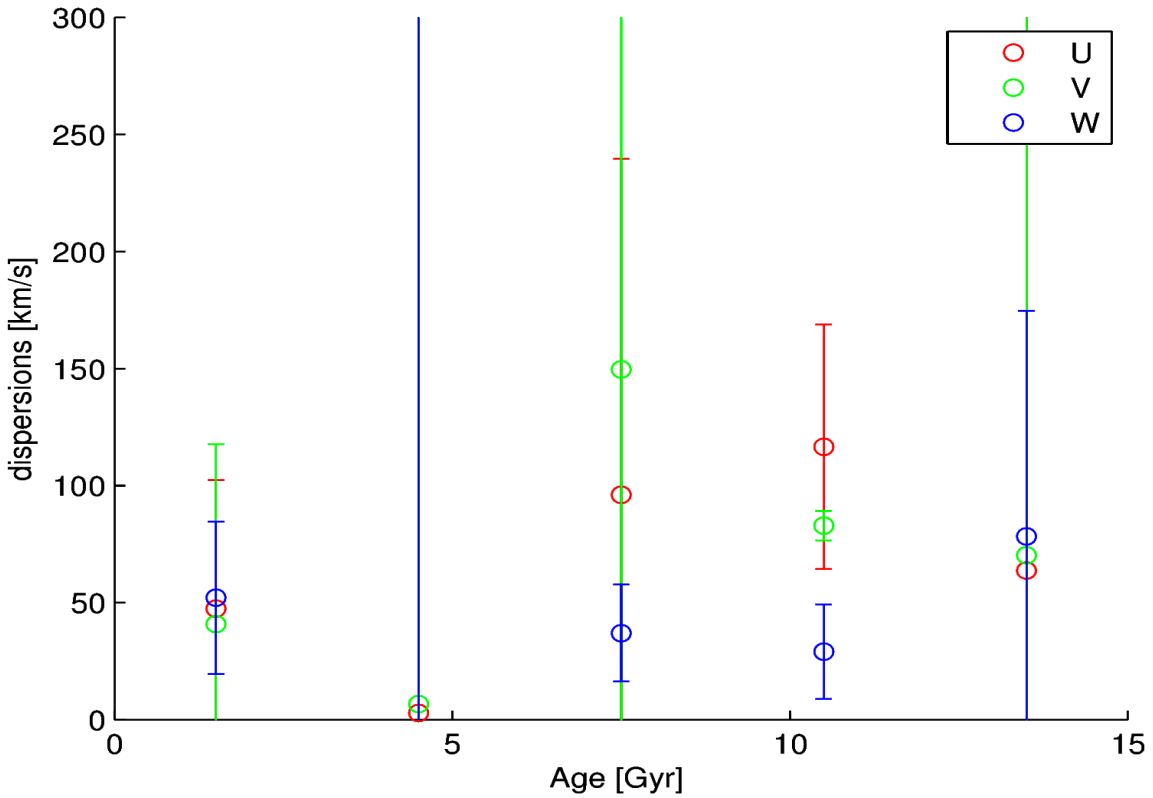



LRa01
LRc01
Cygnus
Perseus
Sagittarius
Carina
Crux
Norma
3-kpc
Sun
Saturn
Gal.
Centre
15
10
5
0
−5
kiloparsecs
−10
−5
0
5
10
ZONA
GALACTICA
INCOGNITA
kiloparsecs

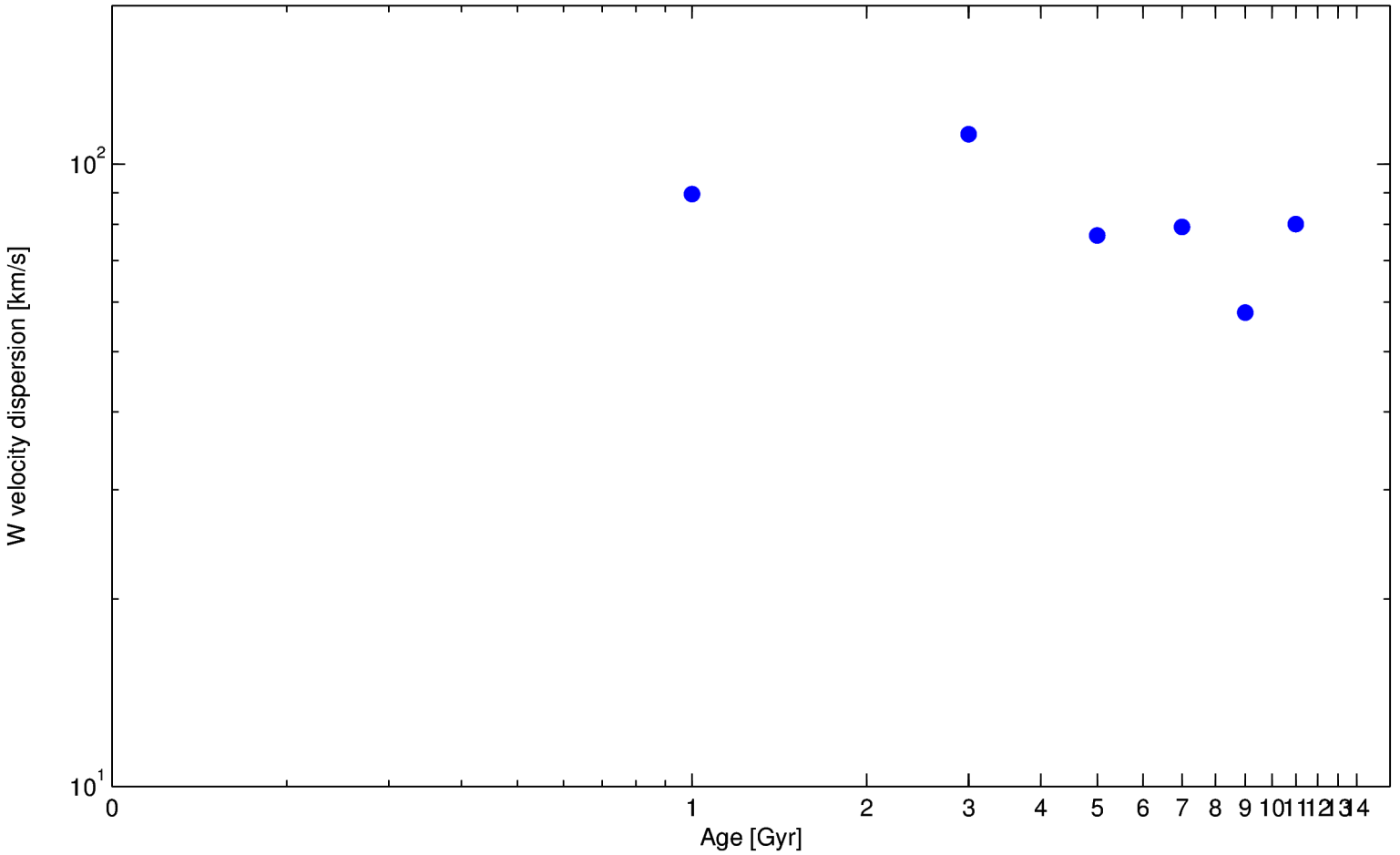
LRc01



LRa01



All


W velocity dispersion [km/s]
10^2
10^1
0
1
2
3
4
5
6
7
8
9
10
11
12
13
14
Age [Gyr]

Proper motions

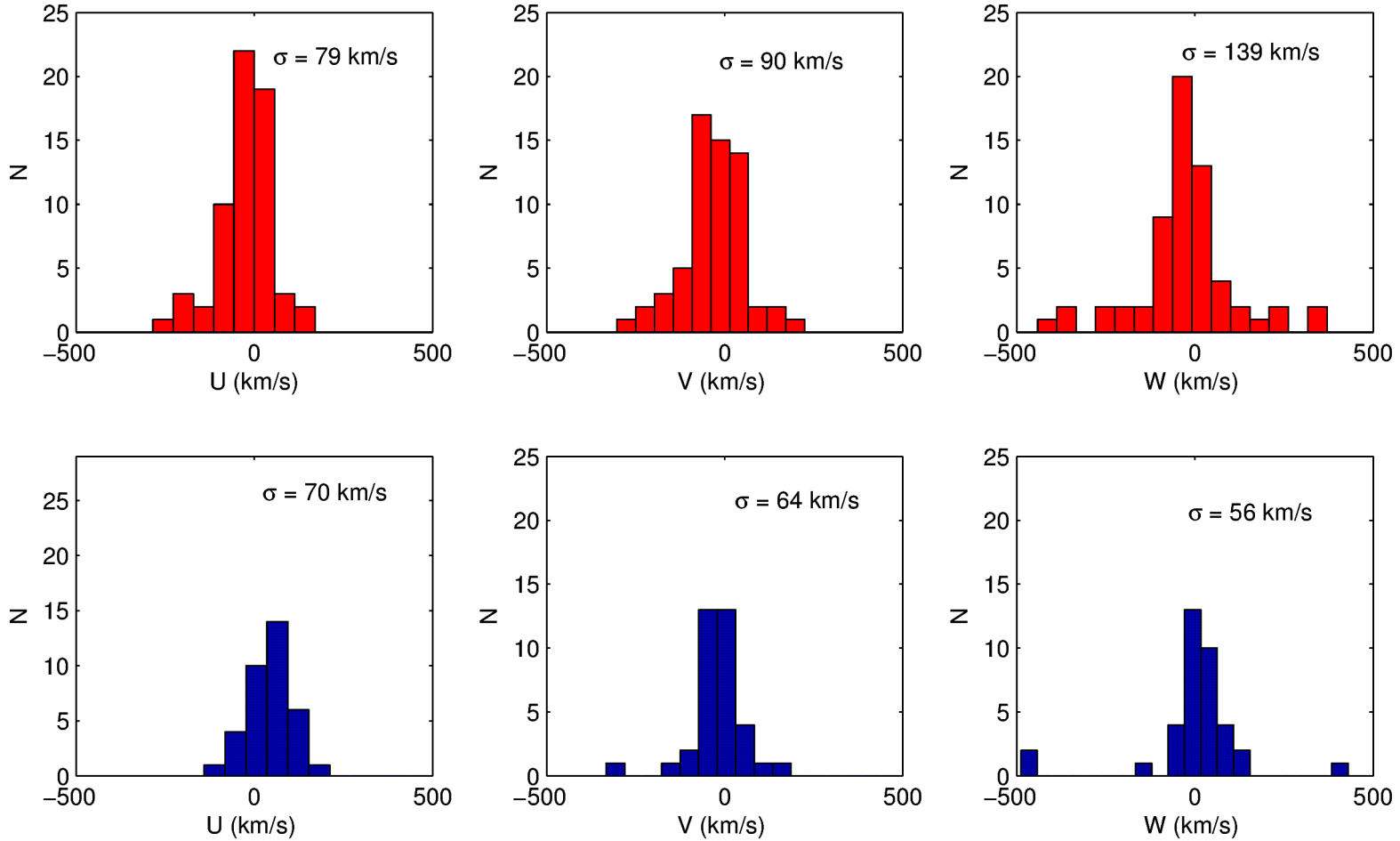
- PPMXL accurate (σ<5mas) for ~99 objects
- Big errors!

field	σ_U	σ_V	σ_W
LRc01 (center)	79	90	139
LRa01 (anticenter)	70	64	56

UVW velocity dispersions of all the stars in the sample with error on pmRA and pmDE $\leq$ 5 mas/yr.

	σ_U	σ_V	σ_W
Z $\leq$ 0.3 kpc ("thin")	43	69	64
Z>0.3 kpc ("thick")	89	79	78

UVW velocity dispersions of all the stars in two samples of different scale height. Only objects with error on UVW $\leq$ 70% were considered.


σ = 79 km/s
σ = 90 km/s
σ = 139 km/s
σ = 70 km/s
σ = 64 km/s
σ = 56 km/s
N
U (km/s)
V (km/s)
W (km/s)
–500
0
500